DOCUMENT RESUME

ED 199 844 EA 013 343

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TITLE A Comparison of Four Survival Ratio Models for Forecasting School Enrollment.
PUB DATE Nov 80
NOTE 15p.; Paper presented at the Annual Meeting of the Mid-South Educational Research Association (New Orleans, LA, November 12-14, 1980).

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Declining Enrollment; Elementary Secondary Education; *Enrollment Projections; *Enrollment Trends; *Mathematical Models; Trend Analysis
IDENTIFIERS *Survival Ratio Models; Tennessee

ABSTRACT

The ratio technique, requiring only simple arithmetic calculations, uses historical information as a basis for projecting school enrollment. In the author's survey of state education agencies, 84 percent of the respondents indicated that they used a ratio technique. This study reviews four different approaches to use of the ratio method in projecting enrollments, utilizing base periods of five, seven, and ten years as well as a weighted average of ratios from a base period of five years. The four methods were employed in an examination of Tennessee's public school districts. Enrollment forecasts were made for the school years 1974-5 through 1978-9. In this paper these forecasts are compared to actual enrollment figures for those years. The computations of the percentage of error for each method and district suggest that forecasts are more accurate for systems with stable or increasing enrollment. Forecasts for systems with declining enrollment were found to be underestimated. No single method was proven to be consistently more accurate than the others under all circumstances. (Author/WD)

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A COMPARISON OF FOUR SURVIVAL RATIO MODELS FOR FORECASTING SCHOOL ENROLLMENT

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NEW ORLEANS, LOUISIANA
NOVEMBER 12-14, 1980

EA 013 343

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In this period of generally declining student enrollment and inflation, the need of school planners and managers for accurate projections of future school enrollments is more important than ever. In general, the public does not view declining enrollment as an important problem facing education, whereas a recent survey of school board members reports that this issue was given the top priority of concern (5). This apparent difference is likely due to the fact that board members focus on a broader range of educational issues (collective bargaining, program cuts, energy costs, staffing, outdated facilities, and funding) than does the general public. Nevertheless, fluctuations in enrollment directly affect almost all aspects of the school program. Therefore, maintaining the best possible information about expected future trends in school enrollment is important at all levels of educational management, particularly the state and local levels.

By far the most popular method used to project school enrollment is the ratio technique. This procedure uses historical enrollment information as a basis for projections. Progression ratios, grade progression ratios, survival ratios, and cohort-survival ratios are names typically associated with this technique. The extensive use of the ratio method for forecasting enrollment was identified through an informal survey of state education personnel conducted by the author. Research personnel in the state education agencies were identified (3) and asked by letter to describe their enrollment

forecasting activities. Of the 35 respondents to this inquiry, 31 indicated that they did enrollment forecasting. Of this number, 26 or 84% indicated that a ratio technique was used. The number of base years used was generally five, seven,or ten. Only four respondents of the 31 who made projections indicated that regression or some combination of techniques was used. This is contrary to previously published recommendations (6, 7). Perhaps the ratio technique is so popular because only simple arithmetic calculations are necessary while methods based on correlations typically require a computer.

To calculate the progression or survival ratio for a selected grade, one computes the quotient of the enrollment for that grade for a given year divided by the enrollment of the next lower grade the year before. The computed ratio indicates what portion of the students "survive" into the given grade. The use of this ratio method for system-wide projections typically involves building a matrix of ratios (rows = grades, columns = base years), averaging the ratios for each grade level, and multiplying the average survival ratio by the appropriate enrollment figure to forecast the next year's enrollment for each grade. By using county births six years prior to the projection year, first grade enrollments can be forecast. The sum of the grade level projections would constitute a projection for the system. By continuing the process, forecasts beyond one year can be made. Projections beyond five years, however, call for the use of estimates of births.

The assumption inherent in the use of the ratio model is that the conditions that existed during the period for which the base data were drawn will exist during the time period to be covered by the projections. Of course, such a stable situation should

not always be expected regarding school enrollment. Modifications of the ratio model where special circumstances arise have been recommended. The use of trend lines (4) or the substitution of the most recent survival ratio (1) have been suggested as ways to incorporate the effects of unusual trends into the model. If a large number of projections are to be made, however, these steps in the process can become cumbersome and time consuming. The use of a weighting scheme that favors more recent ratios from the base period more heavily has also been suggested (2). Since this approach can be applied systematically, it may represent the best way to stress the effects of special or unusual trends without having to treat each situation individually.

Obviously, it is important for projection techniques to reflect trends in enrollments. In an indirect but meaningful way, the selection of the number of base years to be used in the projection addresses this issue. For n base years, n - 1 ratios will be formed in the projection process. By selecting a relatively small base period, such as five years, only the more recent events as reflected in the progressions would be considered as opposed to a base period of 10 years. When a simple average of the progression ratios is used in the forecast, each ratio contributes equally. However, when each ratio is weighted differentially, the projection can be structured so that the most recent ratios have the greatest impact on the projection. Thus, decisions about numbers of base years and weighing schemes are important factors in determining how trends are reflected in the projections.

In general, school systems are experiencing a decline in student enrollment. Some school systems, however, are growing in numbers of students while some others remain relatively stable. This study

addresses the question of whether one of the typically applied ratio projection methods best forecasts enrollment for all school systems when systems having different past patterns of enrollment fluctuations are considered. Also considered in this study is the question of whether or not ratio based enrollment projections are equally accurate for systems experiencing declines in enrollment as for systems with stable or increasing enrollments.

Methodology

Four different approaches to applying the ratio method for projecting enrollments were employed in this study. By varying the number of years in the base period, three projection models using an unweighted average of ratios were examined. The base periods considered were: ten years, seven years, and five years. Also examined were projections resulting from the use of a weighted average of ratios formed from a base period of five years. The weights applied were 1, 2, 3, and 4 with the more recent ratios receiving the heavier weights.

The public school districts in the state of Tennessee constituted the population examined in this study. Since city, county, and special school districts exist with overlapping boundaries, pseudo school districts were defined for purposes of this study. Enrollment in county school districts was the unit of interest with city and special school districts combined with the appropriate county's enrollment where multiple systems existed within a county. Under this definition of school district, the study population of 95 school systems was divided into five groups based on change in net enrollment from the 1964-5 school year to the 1973-4 school year:

(A) Systems whose net enrollment fell by more than 10% (n = 18)

(B) Systems whose net enrollment fell by more than 3% but no more than 10% (n = 29)

(C) Systems whose net enrollment fluctuated between a gain of no more than 3% and a loss of no more than 3% (n = 20)

(D) Systems whose net enrollment grew by more than 3% but no more than 10% (n = 11)

(E) Systems whose net enrollment grew by more than 10% (n = 17)

Data reflecting kindergarten enrollment were not available for the entire 1964-75 historical period and were not considered in any portion of this study.

A sample of five school districts was randomly drawn from each of the five classification groups. The four approaches to applying the ratio method of projecting enrollments were then used to generate a set of enrollment forecasts, one for each of the methods for the sample systems for the school years 1974-5 through 1978-9. Since the actual enrollment figures for these school years are available, the accuracy of the projection methods can be assessed by comparing the actual enrollment figure for each system with the projected figure predicted by each of the methods being studied. A percent of error value was calculated for each of the forecasted enrollments for each combination of system, projection method, and school year. Each system's projected enrollments for a particular year were subtracted from that year's actual enrollment. This amount was then divided by the year's actual enrollment and the quotient was expressed as a percent. By calculating the percentage of error in the manner described, the sign of the result reflects over or under estimation and simplifies interpretation. Multivariate analysis of variance was used to compare vectors of projections in a methods X systems scheme.

Results

Table 1 presents the mean error percents for the 1974-5 (one year into the future) projections for each system type and projection method. Similarly, Tables 2 and 3 present the results of the sets of projections for the 1976-7 (three years into the future) and 1978-9 (five years into the future)[1]. Standard deviations are expressed in parentheses.

The data presented in Table 1 suggest that when ratio methods are used to forecast "next year" enrollment, greater accuracy can be achieved for systems that have exhibited growth or at least stable enrollments (types C, D, and E). Regarding these "next year" forecasts, somewhat larger mean projection errors are associated with systems having historically declining enrollments. It is noteworthy that all of the forecasting methods yielded under projections for system types A and B (declining enrollment systems). While it is unclear whether any one projection method best suits a particular system type, the five year base and weighted means procedures best forecasted "next year" enrollment in "shrinking" systems (types A and B) and seven and ten year base methods yielded the best projected enrollments for the stable and "growing" systems (types C, D, and E).

Table 2 displays mean error percents for projections three years into the future. When compared with the data of Table 1, the ten and seven year base methods were far less effective in predicting enrollment for the "declining" systems than the five year base and weighted means methods. Concerning the group of "stable" systems (type C), the same appears to be true; that is, the five year base

and weighted means methods appear to be superior. For the "growing" systems, the ten and seven year base methods yielded the smaller mean error percents. Over all, the more accurate projections were associated with the "growing" systems (types D and E). Of note is the fact that the mean error percents consistently reflected under projection for the systems having a recent history of declining enrollments.

Data for forecasts five years into the future appear in Table 3. As expected, there is a general decline in the accuracy of the projections as the projection year becomes more remote from the base period. For system types A and B, the weighted means method appears to be the most effective. For the "stable" and "growing" systems, the use of the seven and five year base periods appear to be best. As before, the forecasts for the A and B type systems are characterized by under projection.

In general, the ten year base method generated its most accurate forecasts for the growing systems (D and E). Projections using this method were consistently the least accurate for system types A and B. The seven year base method performed best when forecasting enrollments for system type E but showed some deterioriation in accuracy relative to system types A and B. This was particularly true on the 1978-9 forecasts. The five year base method consistently performed well in predicting enrollments for the stable and growing systems (types C, D, and E) and exhibited no pattern of meaningful decline in accuracy on forecasts three and five years into the future. Over all, the weighted average method provided the best projections for system types A and B even though on the average, these were under projections. Mean error percents for this method were consistently the highest for system type E.

Inspection of the data in Tables 1, 2, and 3 suggests that, on the average, projection errors differ across system type and projection

methods. The results of further investigation of the percent of error figures support this observation. Error percents for each system's three projections were treated as a vector and a two-way MANOVA (projection method X type of system) was used to analyze the data. Significant overall effects were detected for school system type (F=4.25, df=12, 206) and for projection method (F=1.97,df=9,198) at the .05 level of significance. Univariate tests yielded significant F-ratios (.05 level) for system type and projection method for each of the three projection years and a significant F-ratio for interaction for the 1978-9 projections. Concern for sample size and dissimilar dispersion matrices dictates that caution be exercised in interpreting these results. Nevertheless, this preliminary evidence does indicate that projection accuracy may vary depending on recent enrollment trends in the systems and on the method of projection used.

Discussion

The results of this study suggest that, when ratio methods are used, the accuracy of enrollment projections for school systems may vary depending on the kind of enrollment fluctuations the systems are experiencing. Forecasts for systems which have been losing students appear to be less accurate than for systems whose enrollment has been stable or growing. In addition, ratio methods appear to under predict enrollment for systems with declining attendance. Similarly, there is some evidence to suggest that the accuracy of enrollment projections varies depending upon the method used to generate the forecasts. This finding is tentative, however, since no single method was found to be consistently most accurate across system types and sets of projections.

It appears that the accuracy of school enrollment forecasts using ratio techniques is related to the nature of the systems' enrollment

trends. If forecasts for systems with declining enrollment patterns are found to be consistently underestimated, then methods to mediate these errors could be employed on a systematic basis, thus yielding a more accurate set of projections for these types of systems. Whether particular ratio methods can be matched with system types to minimize projection errors is unclear. Hopefully, further work with other modifications to this projection method will yield better information. Efforts to improve regression based forecasts should also be investigated (6,7). Perhaps the use of ridge type estimators could provide more accurate projections.

Notes

1. Tables of mean error percents for projections into the 1975-6 and 1977-8 school years are available from the author.

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Table 1.-Mean Error Percents for 1974-5 Enrollment Projections

System Type	10 Year Base Ratio Method	7 Year Base Ratio Method	5 Year Base Ratio Method	Weighted Ave. Ratio Method	Mean
A	-3.79 (3.69)	-2.91 (3.36)	-2.19 (3.57)	-2.87 (3.14)	-2.94
B	-2.85 (2.46)	-2.28 (2.53)	-1.70 (2.36)	-1.25 (2.07)	-2.02
C	-0.36 (3.56)	0.24 (3.65)	0.56 (3.92)	1.13 (3.26)	0.27
D	0.43 (1.30)	0.81 (1.18)	1.27 (1.12)	1.46 (0.97)	0.99
E	0.60 (1.59)	0.75 (1.40)	1.24 (1.32)	1.51 (1.36)	1.03
Mean	-1.19	-0.68	-0.16	0.00	

Table 2.-Mean Error Percents for 1976-7 Enrollment Projections

System Type	10 Year Base Ratio Method	7 Year Base Ratio Method	5 Year Base Ratio Method	Weighted Ave. Ratio Method	Mean
A	-8.07 (7.42)	-5.60 (6.77)	-3.52 (7.22)	-2.88 (9.26)	-5.02
B	-5.86 (6.12)	-4.40 (6.81)	-2.85 (7.20)	-1.25 (7.57)	-3.59
C	-3.23 (7.45)	-1.69 (6.81)	-0.68 (7.22)	0.61 (5.73)	-1.25
D	-0.99 (4.10)	-0.11 (3.94)	1.55 (3.70)	2.33 (3.54)	0.75
E	-0.54 (4.52)	0.85 (4.70)	2.42 (4.50)	3.54 (5.03)	1.57
Mean	-3.74	-2.15	-0.62	0.47	

Table 3.-Mean Error Percents for 1978-9 Enrollment Projections

System Type	10 Year Base Ratio Method	7 Year Base Ratio Method	5 Year Base Ratio Method	Weighted Ave. Ratio Method	Mean
A	-13.39 (6.81)	-9.63 (5.86)	-6.38 (6.89)	-4.69 (12.19)	-8.52
B	-8.37 (5.67)	-6.20 (6.60)	-3.72 (7.05)	-1.57 (8.90)	-4.97
C	-4.93 (8.53)	-2.69 (7.82)	-1.05 (8.93)	1.23 (6.31)	-1.86
D	-3.18 (3.37)	-1.54 (2.85)	0.71 (2.41)	2.15 (2.33)	-0.47
E	-2.83 (6.55)	-0.79 (6.85)	1.67 (6.44)	3.40 (6.27)	0.36
Mean	-6.54	-4.17	-1.75	0.11	